NASA 3GPP Consideration Topics for Industry

NASA's key considerations for Lunar Surface Networking using 3GPP technology

Not all considerations or topics are applicable to every group.

	Considerations	Comments / Questions From NASA
1	Discuss the feasibility of moving NASA's lunar surface communications architecture toward a primarily 3GPP implementation. In the near term (Artemis V-class), this includes limited numbers of crew, with the following needs: EVA suit audio, rover video/telemetry, and science data. In the longer term, this deployment should be expandable to include more crew and rovers, habitats, and robotic surface elements.	▪ Can we handle critical audio/telemetry and non-critical video in a 10km radius around a lander using 3GPP? ▪ What is the cost and complexity of such a system, and how many elements would it require? ▪ How expandable would the initial infrastructure be?
2	Discuss the cadence of moving NASA's lunar surface communications architecture toward a primarily 3GPP implementation. How quickly can the system be transitioned off legacy approaches? Or do incremental infusion points need to be considered?	▪ As Artemis elements are built, it will be programmatically easier to infuse 3GPP in the initial phases rather than during element update or retrofit. ▪ However, EVA audio communications are considered the highest criticality, and transitioning them to 3GPP will require high confidence to gain acceptance. Do we need incremental infusion points before doing so?
3	Discuss an architecture for an all-IP EVC audio system. How does it handle maintaining voice communications between astronauts when one of them temporarily loses contact with a 3GPP base station? How does it handle maintain voice communications between a group of astronauts who have all lost contact with a 3GPP base station?	▪ What are the implications of replacing a de-centralized audio architecture with an IP-based architecture? ▪ How significant is the computing load to support this, and in which elements must the computing reside?
4	Which 3GPP Release do you recommend NASA target for use in the Artemis V scenario? Describe your rationale, the capability aspects, and technical/implementation risks that influence your recommendation.	
5	Which 3GPP frequency band(s) do you recommend NASA target for use in the Artemis V scenario? Describe your rationale and technical/implementation risks that influence your recommendation.	▪ Are the 3GPP bands recommended in SFCG 32-2R4 proceeding in the right direction?
6	How do the 3GPP frequency bands recommended for an Artemis V mission apply to an Artemis base camp scenario as more elements are added to the surface network?	▪ What is right subset of bands for robust surface network respectful of radio astronomy concerns? ▪ What is a corresponding regulatory strategy to efficiently plan for and implement spectrum updates?

7	Discuss the approach, costs, and risks associated with developing a 3GPP core/RAN implementation for criticality-1 designation. *A crit-1 designation is a system whose failure could result in loss of spacecraft (mission) and crew, and thus requires high reliability.*	
8	Describe the approach, costs, and risk associated with developing criticality-1 3GPP user equipment.	
9	Describe the size, mass, and power consumption of an Artemis V-class 3GPP system. Include solar array or battery power approach and thermal considerations for operation. Provide the terminal, capacity, and service description associated with the mass and power estimates.	▪ What is the interplay between feature set of core and SWaP? ▪ What is the interplay between multi-band (carrier aggregated) RANs and SWaP? ▪ What are the architectural implications of a native 3GPP solution (LTV + EVA suit)? Does it require multi-core with a small cell on LTV?
10	What is your cost projection of an Artemis V-class 3GPP system? Provide the terminal, capacity, and service description associated with the cost estimates.	▪ Both LTV-only 3GPP client and full 3GPP implementation with LTV/EVA suit clients
11	Describe your approach to expand the service network of an Artemis V-class 3GPP system as the number of users (e.g., robotic, human) increase and the required surface area coverage increases with subsequent missions?	
12	Do you have sufficient information regarding the lunar terrain and regolith composition to design and implement a lunar surface telecommunications network? What are the open questions regarding radio frequency propagation on the lunar surface in 3GPP bands of interest?	▪ Can we design radio frequency coverage models sufficient to allow for mission planning?
13	Provide a description, trades, timeline, and risks associated with D2D support sufficient to provide crew-to-crew voice, video, and data communications in the event tower contact is lost.	▪ Can we look to ProSe / V2X even though they are not widely implemented? ▪ Can we lean on a hybrid crit-1 3GPP/Wi-Fi architecture to provide suit-to-suit communications when a base station cannot be seen?
14	Discuss the technical approach and trades associated with base station tower height, determining coverage (terrain effects), and range of	• Can we deploy cell towers tall enough to give the coverage needed by Artemis III (e.g., ~2 km) and coverage for longer distances for later missions (~10 km and beyond)?

	service from a given station location. Identify any needed technology to achieve tower heights anticipated for optimum coverage.	
15	Discuss your plans to provide lunar surface communications and navigation as a service? What steps can NASA take to accelerate commercial implementation and integration of such services.	▪ What spectrum arrangements or business models are needed to attract a commercial operator to the lunar surface?
16	How does NASA plan for multi-carrier lunar surface networks? How does NASA ensure interoperability among multiple service providers?	▪ What is the framework for carriers to share spectrum within the allocated bands? ▪ How will spectrum needs evolve over time as carriers are added? ▪ Do multiple carriers contribute disparate networks and handle network transition with roaming? Do they contribute disparate components (e.g., cores, GNBs) to a unified "NASA" or international network using standardized 3GPP interfaces?
17	What is your current state of readiness of equipment? What are the potential technology gaps to infrastructure or user equipment that need to be closed to meet the envisioned 3GPP use on the lunar surface? Describe your development roadmap as a provider of hardware or services to NASA for lunar surface networking.	
18	What service or capability can you deploy to the lunar surface within 2-3 years, 3-5 years, and 5-7 years? For each timeframe, describe the system architecture and capability. What steps can NASA take in terms of technology or business model to accelerate readiness or deployment schedule or reduce costs?	
19	What is your company's perspective of cost to implement a commercially sourced lunar communications and navigation system or service that meets Artemis requirements? Provide feedback about cost drivers based on your intended segment of this industry solutions (Networking Component Providers, 3GPP System Providers & Integrators, and Commercial Service Providers)	
20	What is your company perspective of the Space Frequency Coordination Group (SFCG) recommendations for spectrum allocation in SFCG 32-2R4	

	with respect to NASA's goals of utilizing the 3GPP standard for lunar surface networking protocols? Does the perspective change for either a government-owned and operated environment/service or a single or multi-provider-owned and operated environment?	
21	Would you be willing to present your information/idea/plan at a NASA workshop that was a) public/general audience, b) limited to civil servants & NASA contractors, or c) NASA civil servants only?	NASA may consider hosting a workshop on the topic of lunar surface networking and wishes to understand industry's desire to participate.
22	How does the number of users (e.g., dozens, hundreds) affect the application and use of telecom standards (e.g., 3GPP) for these types of services? Is there a certain number of users needed to provide a clear benefit to use a certain standard?	
23	Is use of a telecom standard, such as 3GPP, sufficient to ensure interoperability of user equipment with different service providers by adhering to the standard for the lunar surface network? Is anything needed beyond the telecom standard to help ensure interoperability among providers and equipment?	
24	How should the lunar service infrastructure maintain pace with new 3GPP releases?	I.e., Use current release with lunar infrastructure (noting any risks associated with upgrade process) or fewer upgrades and longer periods of time between upgrades or changes to infrastructure to reduce operational risks, but perhaps increased risks of future interoperability.
25	What is the approach/process to modify existing 3GPP-telecom equipment or develop products for use and operation on the lunar surface, including the lunar environment (e.g., temperature, radiation) and operating through the lunar night cycles? Are there any unique aspects of the 3GPP infrastructure to survive the lunar night?	